COASTAL ZONE LAND USE CAPABILITY ANALYSIS

by

Strafford Rockingham Regional Council

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INTRODUCTION

The following section deals with the land-related resources for the coastal zone of New Hampshire. It fulfills in part the relevant sections, Paragraph B of the FY '75 CZM Contract, and (CZM PAR 923, 12 (a)).

TERMINOLOGY

Before a discussion of land use capability begins, it will be helpful to clarify some of the terminology employed. The CZM Act uses the terms "capability" and "suitability". The semantic arguments over the differences between these two terms is enough to make Joyce's Ulysses read like a fairy tale. In that the Act clearly represents an application of the environmental planning method, the term "suitability" is probably most appropriate. The word has become "such a part of the jargon of environmental planning that suggesting an alternative seems counterproductive". (Brandes, 1973.) Because of the confusion raised by the Act and the concern of OCP over the use of these terms, a definition of each, as used in the subsequent discussions, follows:

Capability - the ability of a given natural resource or set of resources on a given geographic site to sustain urban development.

Suitability - the ability of a specific geographic site to sustain urban development based on site "capability" as well as such factors as water/sewer, highway access, and socio-economic demand.

The term development and urban development are used interchangeably to apply to those uses requiring significant physical alterations to coastal lands. These uses might include, but not be limited to: residential, commercial, industrial, and commercial-recreational construction.

The term "natural factor" will refer to a feature such as slope, soil conditions, or groundwater. The term natural factor "category" or "characteristic" will be used interchangeably to refer to a particular type of natural factor such as "0-8% slope" or "sand and gravel" soils. The term natural "resource" is synonymous with both natural factor (eg., "groundwater") and natural characteristic (eg., "aquifer/aquifer recharge areas"). It was used where it was deemed appropriate to the discussion, but not intended to confuse the reader.

METHODOLOGY

As part of the procedure for "defining permissable land and water uses within the coastal zone which have a direct and significant impact upon the coastal waters" (CZM PAR 923 (a)) both an "inventory" and "analysis" of the various land-related "natural and man-made coastal resources" was undertaken (CZM PAR 923, 12 (a) (2)). The aim of this effort was to determine the "capability and suitability for each type of resource and application to all existing, projected or potential uses". (CZM PAR 923, 12 (a) (3)).

If there is one overriding objective in the Coastal Zone Management Act, it must be the protection of coastal waters from the impacts of urbanization. The process of urbanization brings with it several changes or processes that may have major impacts on coastal water resources. On construction sites the removal of vegetation and the protective humus layer increases natural erosion and results in greater stream sedimentation. Sediment in streams promotes such biological and physical problems as noted in Figure 1.

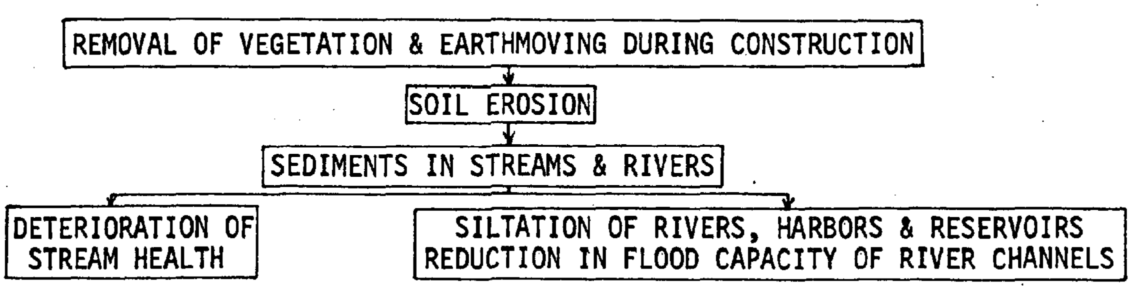

Figure 1. Source: Tourbier, 1973

(See Tourbier for a more detailed discussion of this problem.)

A second major change is the increase in such impermeable surfaces as roads and parking lots that enhances runoff and reduces infiltration of water into the ground. The increased runoff is also of greater velocity, which tends to increase the volume and frequency of floods. This runoff also carries additional contaminants from automobiles, etc. that reduce water quality. The decrease in groundwater recharge means a lowering of the water table. This problem becomes crucial during periods of dry weather when groundwater aquifers feed streams. Lower stream flows decrease the assimilative capacity of coastal waters, thus resulting in degradation of water quality. (See Figure 2.)

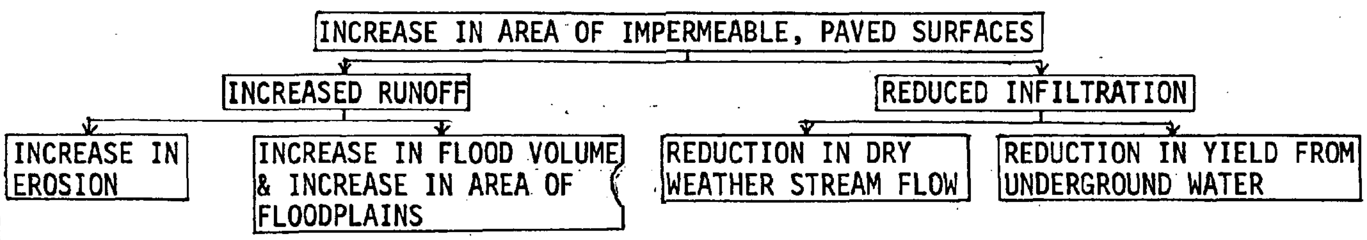

Figure 2. Source: Tourbier, 1973

The third change that occurs from urbanization is the addition of increased waste load to coastal waters from faulty septic tanks (or leakage from sewer systems) or improperly located septic tanks. For instance, a site may be inadequate to handle the septic effluent because of poor drainage. Although malfunctioning systems are not directly attributable to urbanization, it is a long-term problem that can be of great significance in the management of the coastal zone. (See Figure 3.)

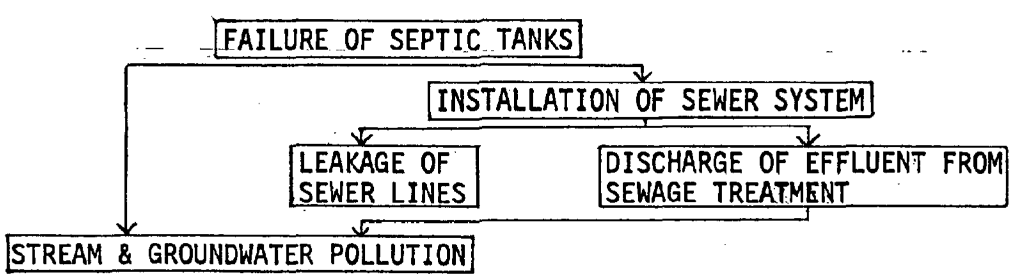

Figure 3. Source: Tourbier, 1973

In considering a model for evaluating the various coastal resources for their ability to accommodate future growth, substantial consideration was given to the objective of minimizing the impacts of the above changes. In effect, this approach relies heavily on the concept of land capability for protection of coastal waters. This approach or model (as well as most other capability models) employs the proposition that the natural environment should significantly determine future land use. Further, by analyzing and understanding coastal natural resources one can determine not only the best places to develop, but also the best places not to develop. The model relies heavily on the protection of water resources by minimizing the impacts of urbanization. For example, freshwater and tidal wetlands are not suited to development. Increased flooding, and decreased water storage and filtering capacity are among the adverse impacts on coastal waters that result from wetland development. Clearly, such a valuable resource was given high value for protection and a low value for urbanization.

Although the "state of the art" in land use planning can employ rather sophisticated models and methods for determining land use capability, such methods require large inputs of time, money, and relevant data. Since such luxuries were not available to OCP or the Strafford-Rockingham Regional Council, a more simplistic, though nonetheless valid approach to land use capability was utilized.

The land use capability model can conceptually be broken down into four parts: (1) Inventory, (2) Analysis, (3) Evaluation, and (4) Classification. However, for the purposes of this discussion, the first three steps will be included subsequently within each section of the relevant natural factor considered in the capability analysis. These four steps are briefly discussed below. The Classification step is discussed at the end of this section.

INVENTORY

In this step all relevant natural factor data and man-made features are collected and mapped. Each factor was broken down into appropriate map categories. For example, the slope map contained the following categories; (1) 0-8%, (2) 8-15% (3) 15-25% and (4) $>$ 25%. Most of the information for the inventory is derived from published sources. For some of the data, however, field investigations were necessary to supplement existing information. The detailed inventory for land-based natural factors was conducted only in the primary and secondary coastal communities (as defined per section 2A of the FY '75 Contract). The data were mapped at a scale of one inch equals 2000 feet using all or parts of the appropriate coastal zone 7½-minute U.S.G.S. quadrangle maps as base maps. The following chart shows the natural factor maps that were completed for each quadrangle. For mapping purposes the relevant portions of the Newburyport East, Mass. Quadrangle was combined with the Hampton, New Hampshire Quadrangle; and the Kittery and Isles of Shoals, New Hampshire Quadrangles were combined.

Paper print maps were used for the Newmarket and Hampton Quadrangles. All other maps were on mylar overlays, except the "Areas of Particular Concern Maps". These were also put on paper prints, because it was much less confusing than using mylars.

ANALYSIS

Once the data were gathered and mapped, they were analyzed to gain a full understanding of the various coastal resources. For instance, wetland soils were discovered to be poorly drained and to act as natural sponges during periods of high runoff, thereby preventing excessive flooding. These facts by themselves had important implications for land use capability.

However, it was soon discovered that consideration of individual natural factors and natural factor categories in isolation was not wholly appropriate. It was not good enough to know just that a particular soil was poorly drained or well drained. Although such characteristics have implications for development by themselves, they become more significant when considered with factors like slope, vegetation, and nearness to water bodies. When these factors are considered together, a better understanding of coastal ecosystems and natural processes can be achieved. This approach also has value because it leads to appropriate land use capability classifications and definition of "permissible land uses".

The Coastal Zone Management Act requires a definition of permissible land uses based upon their impact on coastal waters. In order to assess such impacts a more holistic natural resource analysis was decided upon. If marine estuarine organisms depend on the natural cycle of nutrient flow from upstream waters and land areas, any significant alteration of these areas will have a decided impact on the nutrient flow and thus, the marine habitat. It was crucial then to understand the coastal area as a set of resources interacting over time and space.

EVALUATION

Once the natural factors were fully analyzed, they were evaluated individually for their ability to support general urban development. The "values" attached to the various categories or characteristics of each natural factor were subjective in nature based upon: (1) adopted plans and policies of the coastal zone communities and the coastal regional planning commissions (i.e., Preliminary Comprehensive Land Use Plan for Substate District # 6), (2) state land use policies as expressed in the statutes, such as the Dredge and Fill Act, RSA 483-A, and (3) the best reasoned judgement of the planners at the Strafford-Rockingham Regional Council. These judgements were based upon the following criteria with assistance from expert natural scientists including hydrologists, geologists, and soil scientists:

(1) Potential "cost savings" if area were developed

(2) Presence or absence of physical limitations to development

(3) Whether the resource was a potential "area of particular concern" (See discussion on areas of particular concern)

(4) Potential unreasonable environmental impact if resources were developed.

For example, both the Land Use Plan for Substate District # 6 and the Southern Strafford Environmental Study encourage the preservation of wetlands as adopted policies of the respective commissions. The state has also recognized the value of these ecosystems through RSA 483-A which seeks to protect wetlands from uncontrolled alteration through a permit process. Numerous individual communities (ie. Durham, Rye) have addressed the problem of wetland protection by establishing wetlands protection districts.

Thus the evaluation of soils took into consideration the above as well as other information provided by the Soil Conservation Service. Clearly, soils with high bedrock present greater limitations to development than deep, well-drained soils. The latter soils are preferable for urban development and were rated more highly for this purpose. Assigning values to specific natural factor categories can be done using a relative or numerical scoring system as illustrated below for the soils under discussion.

	Relative	Numerical	
Wetland soils (poorly drained)	low	0	Increasing capability for urban development
High bedrock soils	medium	5	
Well-drained soils	high	10	

For purposes of this study the soils were rank ordered on a relative basis. A further elaboration of the ranking process is found in the Soils section.

The initial evaluation sorted out various natural features into general capability groupings based on their ability to sustain urban development. For instance, 0-8% slopes are more capable of sustaining development than 15-25% slopes. The subsequent discussions for each natural factor makes the specific evaluations clearer. This evaluation represents the initial step in determining geographic "areas of particular concern", permissible uses and determination of priority uses in the coastal zone. For instance, such areas as lakes, coastal wetlands, and aquifer/aquifer recharge because of their inherent vulnerability to man's intrusions become potential "areas of particular concern". On the other hand, better drained, more gently sloping sites are more appropriate for residential, commercial, or industrial uses.

CLASSIFICATION

The formulation of land use capability classes - which translate to more specific areas on the base maps - is based upon the specific values derived from the above procedure. Natural resources that have value for man when left undeveloped (wetlands, etc.) become areas of resource protection, generally analogous to areas of particular concern. (The latter includes areas other than just valuable natural resources. For example, areas that represent unusual economic opportunity may also be considered.) Areas that are more capable of development, are ranked according to their ability to sustain development.

The subsequent section will discuss the inventory, analysis, and evaluation of each of the relevant natural factors in more detail. This will be followed by a discussion of the capability classification system and how the various classes or areas can be related to appropriate coastal zone land uses. (See discussion of Permissible Land Uses).

INVENTORY, ANALYSIS AND EVALUATION

TOPOGRAPHY

The coastal zone lies geographically in what has been called the Seaboard Lowland section of the New England Physiographic province (Fenneman, 1938). Elevations range from sea level to about 200 feet for most of the area. The highest point in the region is Hicks Hill in Madbury -- 320 feet.

The undulating topography of the coastal region generally conforms to the underlying ledge or bedrock, although a number of the hills are composed of glacial deposits. The features of greatest relief are generally the rock-cored hills, such as Great Hill in Newmarket. The other hills are of glacial origin such as Garrison Hill in Dover which is geologically known as a drumlin (a massive deposit of glacial till). Many of the flat sites and river valleys contain swamps and wetland areas. Much of Rye and Durham Point are covered by these wet areas. The wetlands are often flanked by glacial terraces or outwash plains that tend to be very sandy and flat, and are anywhere from 30 to 80 feet higher than the low areas.

It is important to evaluate the topography of the coastal zone, because it provides much of the aesthetic quality that makes the area so unique. Since there are so few areas of relatively high relief, these become a visual asset. In addition to being the most visible elements in the landscape, these prominences provide long views. The scenic and recreational value is of both local and regional significance. These values are expressed as adopted policies in both the Substate #6 report and the Southern Strafford Study which encourage preservation of higher hills and hilltops.

A number of hills were considered as areas of resource protection (see Classification discussion following) and as potential "areas of particular concern". These hills were chosen on the basis of their relative relief. They had to provide unobstructed views of their surroundings and/or be features which provided prominent observable relief from their surroundings. Specific decisions were based on contour map investigation and field observation using these criteria.

EARTH MATERIALS

An investigation of earth materials is important for understanding and evaluating their potential for numerous uses such as water supply, agriculture, residential development, and mineral excavation. For purposes of the Coastal Zone resource inventory only surficial deposits -- those unconsolidated material overlying the ledge or bedrock -- and soils -- the layer of material that extends from the earth's surface to 3-4 feet -- are being considered. Although the ledge or bedrock is an important element of earth materials, it is not of major value in coastal zone planning and will be treated only when it becomes significant to other natural factors, ie., soils.

Surficial Geology

The surficial geology investigation relied heavily on the work of Edward Bradley (1964). Although his studies were somewhat limited, they are the most definitive geologic work done in coastal New Hampshire.

The surficial materials which contribute much to the present day landscape of New Hampshire's coastal area are primarily the result of the last of four continental glaciers, that occurred more than 10,000 years ago. This glacier was a mass of ice about one mile thick which advaqced across New Hampshire from the northwest, then melted and retreated. As it moved across the earth's surface, it deposited a layer of poorly-sorted debris called till. This material is made up of a mixture of sand, silt, clay, gravel, and boulders and is usually 15 to 40 feet thick.

As the glacier began to melt and retreat, debris from the ice was transported and deposited in a seemingly random fashion. (See the Surficial Geology Maps). The sand and gravel deposits (ice-contact) are among the more common surficial materials which were laid down close to the melting ice. They consist of the stratified sands, gravel, and boulders, and vary in thickness to a maximum of 190 feet. Pudding Hill in Madbury serves as an excellent example of such a deposit. These materials are relatively coarse since there was little sorting by the meltwater.

Similar to the coarse sands and gravels, are the outwash sands and fine gravels (outwash). These types of deposits, were better sorted by the meltwater and thus are made up of finer particles than the sands and gravels. Closely associated with the outwash are the sandy shore deposits that formed along shorelines of an ancient sea, which occurred during the latter stages of the glacial period. Both these deposits range in thickness from one to fifty feet and usually occur as broad sand plains as in central Seabrook. These deposits are combined into one category on the Surficial Geology Map -- Outwash and Shore Deposits.

As the ice sheet continued to retreat, the great quantity of meltwater combined with the then ancient sea to create a sea level which extended about fifteen to twenty miles inland from the present sea level. Fine sand, silt, and clay were deposited to a maximum thickness of 75 feet. These marine clays are recognized by their blue-gray color.

Marine clays are generally poorly drained and in many instances highly unstable particularly when wet. And while they may hold a lot of water, they do not easily transmit it (low permeability). Thus, these deposits are generally unsuitable for wells, building sites with septic tanks, and heavy loads.

The surficial deposits have remained much today as they did after the retreat of the glacier and the lowering of the ancient sea to its present level. The only surficial materials that have accumulated recently are the locally poorly drained swamp deposits in low-lying areas and alluvium that has been deposited along streams.

Because of their excellent drainage and high permeability the sand and gravel deposits often provide excellent building sites. They also have a high bearing capacity and are easily excavated. However, there are competing demands for these resources. Because of drainage and load-bearing characteristics they also make excellent fill for highways, etc. The pressure to excavate these deposits is enormous. In addition, some of these deposits can hold large quantities of water (called aquifers); enough in some instances to provide the source of municipal water supplies, such as Dover. It is quite clear that a rational policy of land use regulation be adopted for the more valuable sands and gravels in order to avoid contamination of groundwater supplies.

In order to satisfy the competing demands for this resource, a multiple-use policy should be adopted. Initially this would include a detailed hydrologic study of the coastal area to determine the best sources of water, including both ground and surface water. Once this has been completed, regulations can be adopted to protect the most valuable aquifers while the other sand and gravel deposits can be used for development and excavation.

The valuable sand and gravel deposits were identified on the Areas of Particular Concern Map. The critical aquifer/aquifer recharge sands and gravels were also identified as areas of particular concern on this map. These areas are further discussed in the groundwater section of the inventory. Where geologic sands and gravels coincide with sand and gravel soils, they become identified as areas more capable of development. These areas are dealt with more specifically in the soils section of the inventory and the land use suitability section of the classification discussion.

Soils

Soils form the upper organic layer of earth materials which have developed from the interaction of climate, vegetation, slope, and surficial geology. The present characteristics of each soil type are highly dependent on its position in one of the major sufricial deposits. For example, the Hinckley and Windsor soils are located in the level portions of sand and gravel deposits. (See Figure 1.)

The soil conditions maps are interpreted from the Strafford and Rockingham County Soil Surveys, since communities from both counties are within the primary and secondary coastal zone. Although all the inventory maps have essentially the same soil categories, the Strafford County section of the region has generally more accurate and reliable information. This is due to the fact that the 1959 Rockingham County Soil Survey was done for agricultural pruposes and with less accuracy control. The Strafford County Survey was completed in 1973 and the soils interpretations were done for a variety of uses including suitability for community development, forestry, wildlife, and recreation as well as agriculture. For purposes of the inventory and land capability mapping, the existing

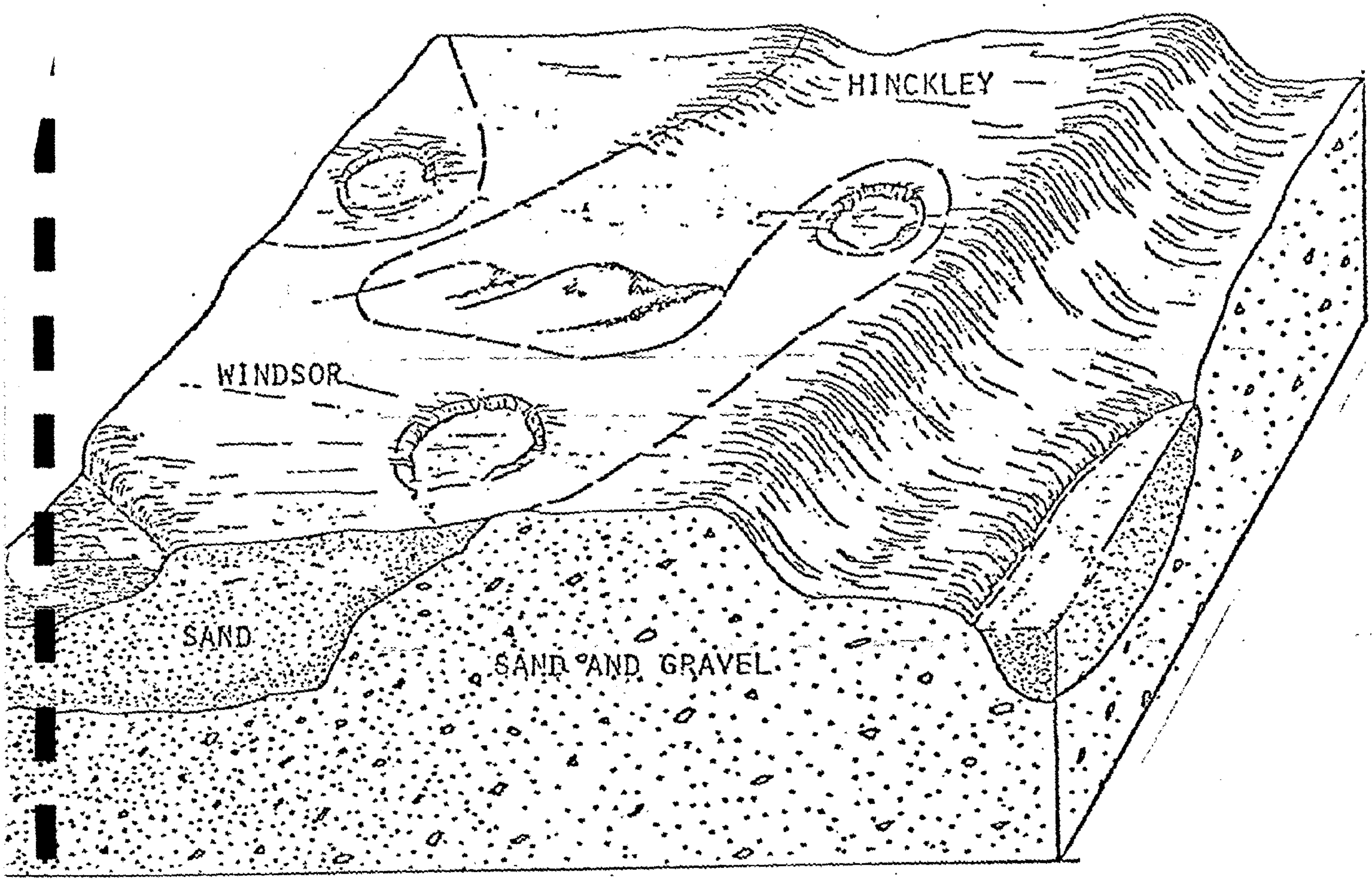

Figure 4. Typical pattern of soils and underlying material in the Hinckley-Windsor-Saugatuck association.

Source: S.C.S., Soil Survey of Strafford County, New Hampshire, 1973 soil information was considered to be of equal value. However, it must be emphatically stressed that the soil information and capability analysis is much more accurate and defensible in Strafford County than in Rockingham County. The Soil Conservation Service will legally stand behind the Strafford County Soil Survey, but not the Rockingham Survey.

Soil conditions are a major factor in determining suitable locations for such urban uses as residential development and recreation. Below is a description of each soil condition category with suggested recommendations for potential development. The formulation of these soil categories and their appropriate ranking were based in part upon the advice and values expressed by the Soil Conservation Service. Although S.C.S. will not legally stand behind these categories for management purposes, the staff of the Council feels strongly that the rank ordering developed below is appropriate. Again the Substate Six Plan and the Southern Strafford Report in part address the problem of "value" setting. Both encourage preservation of wetlands while the latter encourages strict regulations in seasonally wet soils. S.C.S. discourages development on highly erodible soils on steep slopes. The remainder of the soils were evaluated by the staff on the basis of their ability to physically accommodate urban development. Below the soils are listed generally according to their capability for urban development, from least to most capable based upon the judgemental process outlined above.

Wetland Soils

These usually formed in association with the marine silts and clays, the sand and gravel deposits, till, and the more recent alluvial sediments deposited by streams and rivers. They include all the poorly drained mineral and organic soils, i.e., those having a water table at or near the ground surface for seven or more months of the year (Kelsey, 1973-74).

Wetland soils are best left undeveloped because many occur in natural drainage ways and are valuable when left untouched. Not only do they act as natural sponges to collect excess runoff, thus preventing flooding downstream, but they also serve as a habitat for fish and wildlife. These areas have open space and recreational potential. Because of their ecological value wetland soils (including tidal wetlands) have been recommended as "areas of particular concern". See Areas of Particular Concern discussion for more details.

Highly Erodible Soils

The highly erodible soils are located in marine clay deposits, often adjacent to the tidal rivers such as the Cocheco. Development on these soils is generally not recommended, because of the high potential for erosion and stream pollution. They are best left in vegetative cover. Where construction is necessary, proper erosion and sediment controls must be used. Since the erosion and sedimentation potential of these soils is so great, they have been recommended as "areas of particular concern" in the Primary Zone.

Seasonally Wet Soils

These soils formed in association with parent materials similar to those of the wetland soils, although they are generally better drained. This group includes all moderately well-drained soils or those having a water table within 1½ to 2½ feet of the ground surface during parts of the year (Kelsey, 1973-74).

Development of seasonally wet soils should be avoided where at all possible. Wet basements and submerged leach fields of septic tanks can be expected, with a distinct possibility of groundwater pollution. Only when waterproof municipal sewer facilities or similar protective measures can be provided should these soils be developed. Waste disposal and fertilizer application should be discouraged.

Shallow to Bedrock Soils

These soils are located on thin deposits of glacial till. Bedrock or ledge in much of the delineated areas is typically 30 inches or less below the ground surface. Shallow to bedrock soils are so thin to bedrock that high density or commercial development is usually unwise because of high costs of constructing foundation and septic tanks or sewer lines. Any kind of development should be of low density on large lots. However, a community may want to overcome the bedrock limitation by constructing water and sewer facilities to serve high density development, which would offset the cost of these services. Newmarket is a good example of this practice.

Clays and Sands Over Clay Soils

The group consists of all well-drained clays and all well-drained sands over clay soils. Although these soils are generally well-drained, they are somewhat slowly permeable because of the clay layer. As a result a drainage system around the foundation is suggested to carry off water to a settling pond or storm sewer. This system can be quite expensive, but needed in order to avoid any possibility of flooded basements. No on-site septic systems should be allowed because of the potential for groundwater pollution. Only developments that can afford to offset the above limitations should be considered here.

Deep, Well-Drained, Stony (with hardpan) Soils

These soils occur under the same conditions as the above but typically have a hardpan at about two feet that restricts the downward and lateral movement of water (Kelsey, 1974-75).

While the deep, stony hardpan soils may be well-drained, on-site septic systems should not be used on small lots. The moderately slow permeability and the possibility of a perched water table above the pan are limitations that could lead to groundwater pollution. Development with water and sewer is recommended especially where densities are relatively high.

In Rockingham County the previous two categories are combined into the following one, since there was no distinction in the soil survey between those deep stony soils that had a hardpan and those that did not.

Deep Stony Soils

This group of soils formed in glacial till and comprise all well-drained and small areas of poorly-drained stony soils. These soils may or may not have hardpan layers. These soils have the same limitations as the deep, well-drained stony, hardpan soils of Strafford County.

Deep, Well-Drained, Stony (non-hardpan) Soils

The deep well-drained stony group consists of well-drained loamy soils that are formed in deep, sandy, stony, glacial till.

Although these soils are quite variable in character, most types of development can be considered. The only limitations are stones and clay lenses that might hinder foundation and septic tank construction and drainage.

Sandy and Gravelly Soils

This group includes all well-drained to excessively well-drained soils that have formed in thick sand and gravel deposits.

Sand and gravel soils have the best potential for development since they offer few if any restrictions to construction. However, intensive development with impervious surfaces (roads, parking lots, etc.) can prevent recharge to the groundwater reservoirs in these deposits which may be needed for future water supplies. In addition, if septic tanks are used, they must be carefully constructed and regulated to prevent groundwater contamination from the effluent. High density development must definitely be discouraged in sand and gravel areas where municipal wells are located. The Groundwater section of the inventory covers this more fully.

Prime Agricultural Soils

Prime agricultural soils were also designated in the inventory, although not on the soils condition maps. Criteria used to determine these soils were determined by the Soil Conservation Service. Because of the long-term value of such soils these areas were recommended as Areas of Particular Concern. See that section for a more detailed discussion of these areas. Both the Substate Six Plan and the Southern Strafford Report encourage maintenance of agricultural and prime agricultural lands as policy.

In conclusion, it must be recognized that neither soil survey is accurate to the site specific level, particularly Rockingham County's Therefore, rigid land use regulations should not be formulated for specific soil categories or soil types. Where land use ordinances depend on soil criteria, standards and regulations should be flexible enough to allow intelligent planning and management decisions. Such requirements as on-site investigations for certain types or sizes of development is one method for encouraging good planning.

SLOPE

Consideration of slope or steepness of the land in the natural resource inventory is important, because it plays a significant role in the capability of any site for most land uses. For instance, flat sites are suitable for such uses as roads and highways, large commercial and industrial buildings, agriculture and intensive recreation. As the slopes become steeper many of the uses are not suitable. In addition, development and service costs increase. The greatest hazard from development on any but the flattest slopes is erosion. As the slope gradient increases the potential for erosion and water quality deterioration is greatly enhanced. These conditions become of critical concern particularly in the Primary Zone where there is potential for significant impact on coastal waters.

Using the U.S.G.S. contour base maps four categories of slope were designated: 0-8%, 8-15%, 15-25%, and 25% and greater. Percent slope is determined by expressing the vertical change as a ratio of the horizontal change. For example, a vertical change of 5 feet with a horizontal change of 20 feet is equivalent to a 25% slope. These categories were developed by the S.C.S. and have been in use in the northeastern region of the United States for many years. According to Pilgrim (1976), the slope categories were based upon two major factors: (1) the major landscape units in this region of the country correspond to these categories and (2) the agricultural land management programs recommended by the S.C.S. used these slope breakdowns with success. In addition, recommended soil limitation categories (slight, moderate, severe) for excavating dwellings, septic tanks, etc. rely heavily on these slope breakdowns (Soil Conservation Service, 1971).

Slope limitations for most uses become severe or critical when the slope is 15% or greater. Both S.C.S. and the Southern Strafford Report regard steep slopes as areas of hazard and potentially significant environmental impact if developed. Numerous subdivision ordinances in the coastal zone communities also address this problem.

Based upon the above considerations the slopes were rank ordered from least to most capable using the S.C.S. slope breakdowns. See Figure 5.

Some suggested land uses for each slope category: 1/ 2

0-3% Flat lands are suitable for most large buildings -- industrial and commercial. Roads, highways, and active recreation uses such as ball fields are also suitable for these flat areas. Very flat sites may pose such problems as (1) inadequate drainage especially during peak storms; and (2) inadequate gravity flow for sanitary sewers.

3-8% These gently undulating areas are suitable for single family housing on small and medium lots, apartment buildings, secondary roads, as well as most of the activities above, with increasing limitations at the upper extreme of the category.

8-15% Development costs and the potential for runoff and erosion begin to increase. These areas are suitable for single family housing on large lots, townhouses, and garden apartments.

15-25% Townhouses with multi-level entrances, using the cluster technique, can be considered in these areas. The cost of development becomes a major factor. Runoff and erosion control is essential. These slopes have been recommended for inclusion as Areas of Particular Concern in the Primary Zone.

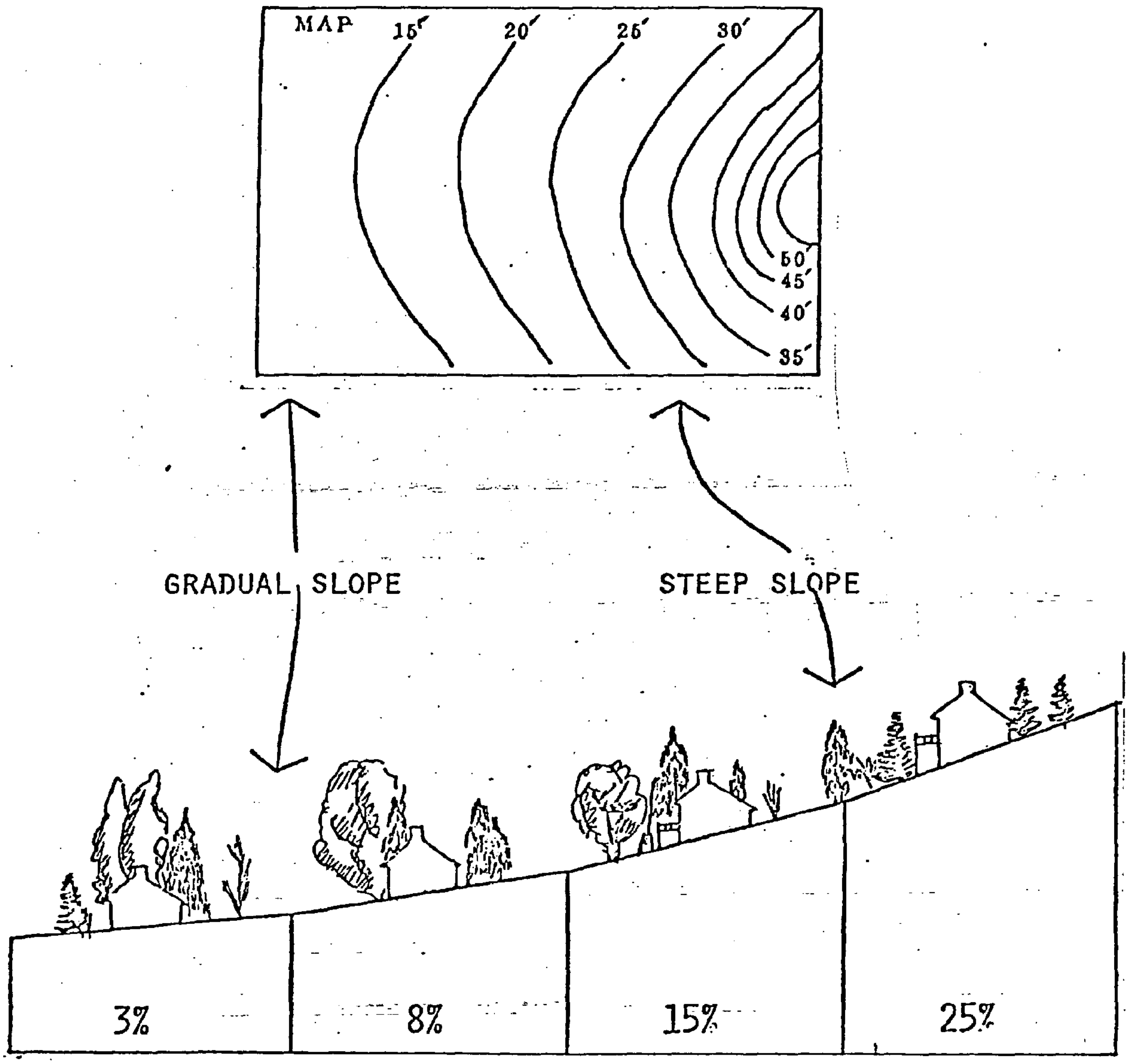

Figure 5. Diagram to illustrate percent slope.

25% and over	Almost all development should be prevented. Development costs and potential environmental impact are high. Such factors as shallow depth to bedrock, drainage problems, runoff and erosion severely limit construction on these slopes. For these reasons such slopes in the Primary Zone are also recommended as Areas of Particular Concern.

GROUNDWATER

Groundwater occurs in openings or pores in the bedrock or surficial materials. The amount of water that these materials can hold depends upon the size and number of the openings and the particle size of the geologic material. If a geologic deposit or unit has numerous openings it is said to be porous. Permeability is the capacity of a given geologic unit to transmit water. In order to have large yields of groundwater, the deposit must have high porosity and permeability. Since sands and gravels have large particles and large pore spaces, they are permeable enough to produce high yields of groundwater. This type of deposit is called an aquifer (a geologic unit that yields significant amounts of water).

The chief source of groundwater is precipitation. Of the precipitation that falls to the earth's surface a small fraction runs directly off the surface, while much of it flows toward streams just below the earth's surface by means of a process called interflow. Much of the rest returns to the atmosphere through evaporation from surface water or transpiration from vegetation (evapotranspiration). In the coastal area of New Hampshire, of the approximately 42 inches of precipitation received annually, half or about 21 inches is lost to evapotranspiration. The remainder infiltrates through the soil to recharge the groundwater. The point at which the geologic unit is completely saturated is known as the water table. See Figure 6.

The best potential aquifers in New Hampshire's coastal zone are the large sand and gravel deposits. See Groundwater Potential Maps, Good Potential Areas. Because of their excellent permeability, yields as high as 700 gallons per minute

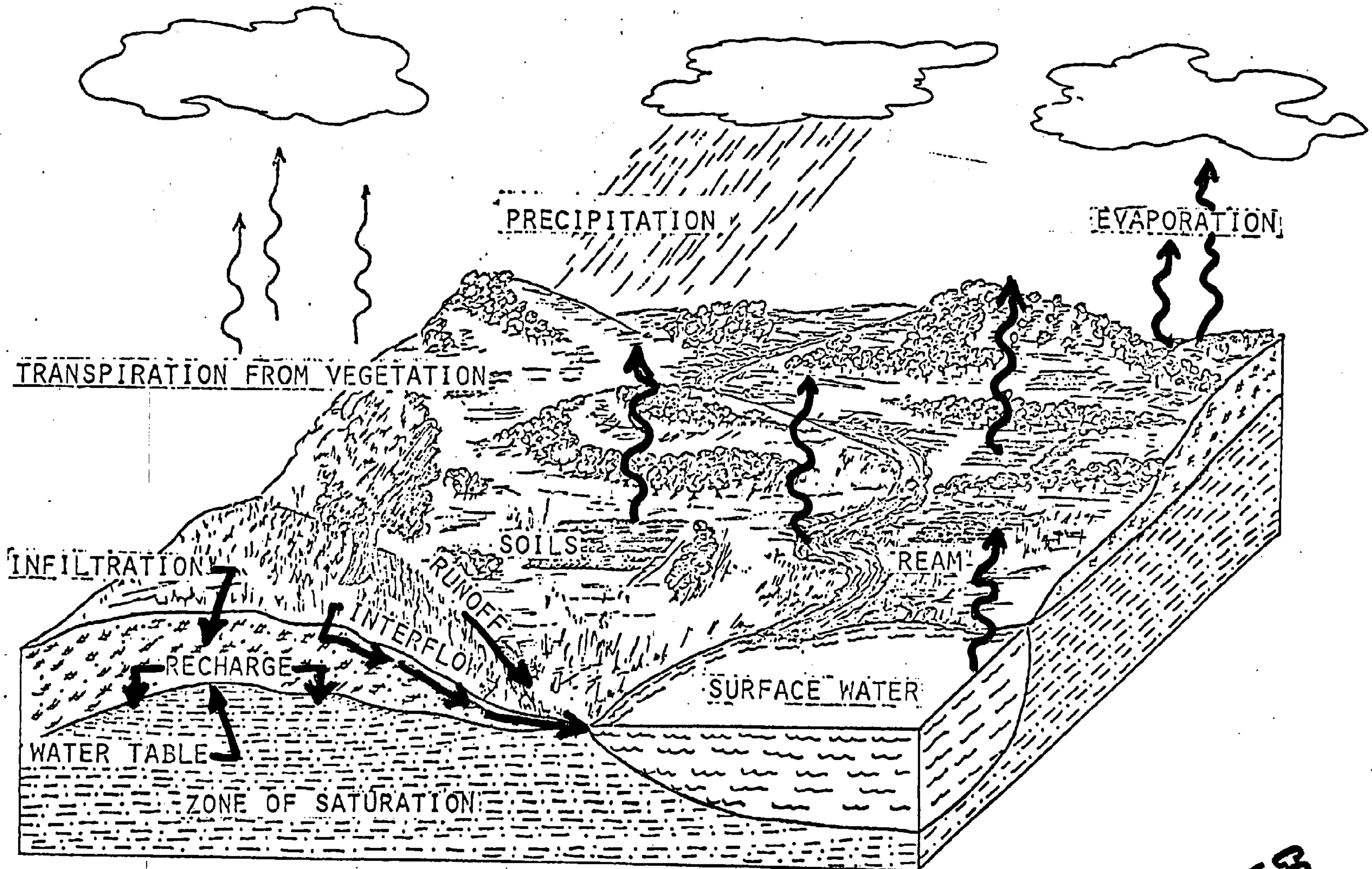

Figure 6. Relationship of Groundwater to the Hydrologic Cycle.

(gpm) may be obtained (Bradley, 1964). On the Groundwater Potential Maps these areas are either in dark blue or coded as the number 1 (good potential). In some instances these deposits are too thin or too small to provide sizeable reservoirs of water. These are indicated by medium blue color and categorized as moderate potential.

The outwash and shore deposits are moderately permeable and can be expected to yield up to 100 gpm (Bradley, 1964). This kind of yield is suitable for residential, farm, and small industrial supplies. Where well-sorted medium or coarse sands occur in known ancient geologic valleys, the saturated thickness may be quite deep. According to Cotton (1975) these aquifers could yield over a million gallons of water per day. Field work is necessary to make determinations about such deposits and is highly recommended.

Till and marine clay have generally poor potential for anything but domestic water supplies although the groundwater potential maps have distinguished between the two. This was done to indicate a potentially good supply of water under the marine clays. In some instances these clays lie above excellent sand and gravel or outwash deposits, particularly adjacent to rivers. This situation occurs along the Exeter River in Exeter where the town has a municipal well. The small areas of alluvium and swamp deposits were classified as poor potential.

Of all the natural resources, groundwater is probably the single most limiting factor to the amount and type of development in the coastal zone of New Hampshire. Right now groundwater is the principal source of water in the area. According to Hall (1974) of the 16 million gallons per day water consumption in the seacoast area, 10.5 mgd comes from groundwater. Present population projection indicates that the seacoast area will run out of groundwater supplies by the middle 1980's. This is based on a sustained water yield figure of 25 mgd, which both Hall (1973) and Anderson-Nichols (1969-72) calculate. It is quite clear that the coastal area is facing a potential crisis. In order to meet this need, new sources of water will soon have to be developed either locally or from outside sources. Any such water supply development should be coordinated with growth management policies.

For these reasons, it is essential that groundwater resources be protected from contamination in areas that are presently being used as water supplies or that are potential future water supplies. These areas include many sand and gravel deposits as well as some outwash and shore deposits. In some instances medium density development on water and sewer is appropriate in these areas. It is important to prevent incompatible uses, such as oil storage facilities, that might lead to groundwater contamination. Growth should also be controlled to regulate the amount of impermeable cover, such as roofs and parking lots, in order to maintain adequate recharge of the aquifers. See Mettee (1974) for a more detailed discussion of groundwater and its implications for growth in the coastal area of New Hampshire.

For purposes of the inventory mapping, the surficial deposits were interpreted for their ability to yield water. The categories for the Groundwater Potential Maps are:

Class	Deposit
1) Good Potential	- Excellent sand and gravel aquifers
2) Moderate Potential	- Thin or small sand and gravel deposits
3) Poor Potential	- Till, Alluvium Swamp deposits, Marine clays*

* These were distinguished from the other deposits of poor potential. While they usually are of poor potential, they often overlie extensive sand and gravel aquifers as noted in the discussion. It was decided that this circumstance was worth noting.

Because of their present and potential water bearing capacity, those sand and gravel areas in the Good class have been recommended as Areas of Particular Concern. The Southern Strafford Study recommends protection for these aquifers.

SURFACE WATER

The Surface Drainage Maps indicate the relative vulnerability of the various sub-basins in the primary and secondary coastal zone which are part of the Coastal Watershed.

Each stream or basin on the surface drainage maps is assigned a stream or basin order designation based upon the tributaries of each stream. For instance, a headwater stream with no tributaries is classified as a first order stream while a second order stream has at least two first order tributaries, and no tributary larger than a first order. Similarly, a third order stream has at least two second order tributaries, and no tributaries greater than a second order.

This drainage basin approach has been used in the scientific community as a means to identify and describe erosional and drainage characteristics of the landscape (see Horton and Strahler). It has been adopted for planning purposes in several studies using the concept of assimilative capacity (see Metcalf and Eddy, p 673, 1972 and Parker, H.W. , p 119, 1975) to determine land capability as explained below. (See Atlanta Regional Commission, 1972 and Frederick, Jr., C.J. , 1972.) Although there are no specific regional or local policies that address surface drainage, both the Substate Six Plan and the Southern Strafford Study have stated policies with regard to water resource protection. It is the judgement of the staff that the above system has scientific merit and is appropriately used here.

In general, surface water that originates at the headwaters of small watersheds are most vulnerable to impacts from development. They have less water volume to assimilate contaminants and dilute solids than do surface waters that have flowed through several stream orders before reaching major rivers. First order basins are the most sensitive to disturbance, since these tend to be located at the headwaters and have very low flows. Any significant changes that have adverse impact on these streams are felt in varying degrees throughout the drainage system. Urbanization in such areas increases surface runoff and causes increased erosion and siltation. Since ponds and lakes are particularly vulnerable to the impacts of development, they are considered to be in the same class as the headwaters or first order basins. The textured overlay on the maps indicates a buffer zone of protection around these major water bodies. The exact width of this buffer is not crucial at this point, but a distance of between 100 and 300 feet is reasonable (see Strong, Keene, et. al., 1972). The recommended regulations will treat this buffer concept more precisely.

The coastal zone has many first order basins. Because these basins have little stream flow capacity, they have little assimilative capacity. Therefore, the first order basins are much less desirable to develop than the second, third, and fourth order basins.

Second order basins are less vulnerable than first order. This system continues successfully so that the fourth order basins are the least vulnerable or the most appropriate for development. These basins have been interpreted by the SRRC staff from the U.S.G.S. topographic maps, 15 minute series.

WATER AND SEWER

Although these systems are man-made, they were treated here because of the important implications they have for development and defining "permissible land uses" in the coastal zone. The connotation of "suitability" is introduced when these types of factors are considered.

The majority of the towns and cities in the coastal area have municipal water and sewer systems. The Water and Sewer Maps indicate the extent and coverage of each of these systems. These services generally lie within the major population centers of these communities such as urban areas of Dover and Portsmouth. These maps were based on information and maps provided by the appropriate communities.

These facilities provide flexibility to growth patterns because they allow developers the opportunity of overcoming some of the natural limitations to urban growth such as high bedrock or ledge. Where it is appropriate a community can develop at higher densities than with private wells and septic systems. Clustering of development on such facilities encourages a wiser use of land and is generally more economical in the long run. However, provision of water and sewer services does not imply that any kind of development can go anywhere. Critical areas such as wetlands and steep slopes should still be avoided. For environmental and long-term economic reasons these areas should be protected through proper land use regulation.

It is not the purpose of this study to make specific recommendations for future water and sewer systems. However, it is recommended that where possible communities should cooperate in construction of such facilities. This approach would allow greater system flexibility and would result in lower long-term costs to the communities involved. It is also recommended that water and sewer planning be done on a watershed basis for ecological and economic reasons.

CLASSIFICATION

Once the various natural factors of the Coastal Zone were evaluated for their ability to support urban development, capability map classes were defined based upon the convergence of given natural factor characteristics. For example, since 0-8% slopes, sand and gravel soils, and fourth order drainage represent the most propitious natural characteristics for development, they were synthesized in Capability Class 1.

At the risk of making a relatively simple process become complex, it was decided that the capability classes should identify the specific natural characteristics that were in convergence. The alternative would have been to aggregate more characteristics into one class, resulting in fewer capability classes. By using the former process loss of valuable data was kept to a minimum in going from the individual factor maps to the land use capability map. Such a system of natural factor synthesis requires numerous capability classes. However, it is infinitely easier for prospective users to determine, when necessary, specific resources from the capability map, rather than continually referring to individual natural factor maps. By definition, Capability Class 1 in the previous example illustrates this point.

At the same time OCP requested that these numerous individual classes be aggregated into four capability classes, which for the sake of simplicity will be referred to as capability "areas" in the discussion. This procedure was followed and the individual map legends reflect both systems of classification. In the aggregated system Capability Class 1 becomes Capability Area 1 or those areas representing "Excellent" capability for development. The capability classes and areas are defined at the end of this section.

More specifically, the process of mapping the various capability classes was achieved through an ordered overlay technique. The first step was to extract from the individual factor maps those areas which by the evaluation process were considered to present particular hazards for development (e.g., floodplains) or to represent areas of high social, economic, or environmental cost (e.g., coastal wetlands) if improperly developed. These resources fall into what was defined as a resource protection district or the "Poor" development capability area. This area (district) represents a grouping of resources that leads to an initial determination of "areas of particular concern". The term resource protection was employed to identify those areas whose integrity should be protected for the good of the whole coastal zone community. Such a designation does not imply that these areas not be used, but only that uses commensurate with the tolerance of the resource be allowed. Special regulations for these areas may be needed.

Each resource has been numbered and colored where appropriate and identified in the map legend. These resources are listed below, generally in decreasing order of criticality or value from top to botton. See Areas of Particular Concern discussion for an expanded discussion of these resources.

The next step was to identify the capability of the remaining areas on the maps based on a particular combination of soil conditions, slope, and surface drainage. Each of these maps was overlaid successively to determine the various capability classes on each of the seven Land Use Capability Maps. Twelve capability classes ranging from most capable (#1) to least capable (#12) for urban development have been designated. On the capability maps these have been coded appropriately so that they are easily identifiable. To satisfy the request of the state, these twelve classes have been divided into three groups. The dividing points were chosen because in each instance there was a significant enough change in one or more of the resource characteristics (categories) to warrant a division. These groups were identified as follows: Excellent potential for development, (Capability Area 1), Good potential for development, (Capability Area 2), and Fair potential for development, (Capability Area 3). They are defined below.

Where water and sewer are available the capability of a given area will usually improve. While these factors were not considered in the capability analysis per se, they will provide an essential element in determining "permissible land uses", as discussed in a subsequent section.

This classification system leads to a definition of "permissible land uses" for the coastal zone. Knowing the inherent capability of the coastal zone for urban development, and then assessing the requirements for various land uses, the most appropriate uses can be guided to the most capable areas. Industrial development could be appropriately accommodated on Class 3 land (Excellent potential for development) but not on Class 9 land (Fair potential for development).

Land Use Capability Classification

Capability Class	Slope	Soil 1/ Condition	Surface Drainage
Capability Area 1 - Excellent Potential			
1	0-8%	1	Fourth Order
2	0-8%	1	Second, or Third
3	0-8%	1	First; Lake Shore Buffers

Land Use Capability Classification

Capability Class	Slope	Soil 1/ Condition	Surface Drainage
Capability Area 2 - Good Potential			
4	0-8%	2	Second, Third, or Fourth
5	0-8%	2	First, or Lake Shore Buffer
Capability Area 3 - Fair Potential			
6	0-8%	3	First, or Lake Shore Buffer
	8-15%	1	Second, Third or Fourth
7	8-15%	1	First, or Lake Shore Buffer
8	0-8%	3	Second, Third, or Fourth
9	8-15%	2	Second, Third, or Fourth
10	8-15%	2	First, or Lake Shore Buffer
	8-15%	3	Second, Third, or Fourth
11	8-15%	3	First, or Lake Shore Buffer
12	15-25%	1, 2, or 3	Any drainage

Capability Area 4 - Poor Potential (Resource Protection)

1. Floodplains 2/ and/or Wetlands 3/
   Highly Erodible Soils 3/
2. Floodplains and prime agricultural land 3/
3. Floodplains
4. Wetlands in Valuable Forest Areas 4/
5. Wetlands
6. Highly Erodible Soils on Steep Slopes 5/
7. Highly Erodible Soils
8. Steep Slopes in Valuable Forest Areas
9. Slopes over 25% 6/
10. Ice-Contact Deposits in Valuable Forest Areas
11. Ice-Contact Deposits
12. Prime Agricultural Soils
    Natural Areas 7/
    Higher Hills 5/

1/ Soil Conditions Groups

1. Sand and Gravelly Soils
   Deep, Well-Drained Stony (non hardpan) Soils

2. Deep, Well-Drained Stony Hardpan Soils
   Clays and Sands over Clayey Soils

3. Seasonally Wet Soils
   Shallow to Bedrock Soils

2/ S.C.S. 100-year floodplain boundaries and 10 foot boundary for all tidal waters based on Hall (1975), Hayden (1975), and Corps of Engineers (unknown).

3/ S.C.S. Rockingham and Strafford Soil Survey

4/ Brunz and Lane (1969), "A Timber Inventory of the Seacoast Region".

5/ U.S.G.S. 7½-minute quadrangles

6/ Bradley (1964), Geology and Groundwater Resources of Southeastern New Hampshire, Cotton (1974), personal communication

7/ Natural Areas Inventory, Society for the Protection of New Hampshire Forests

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